LANGUAGE-SPECIFIC PATTERNS OF SEGMENT PROLONGATION IN HUNGARIAN

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Abstract

Segment prolongation has been shown to be one of the most common forms of non-pathological speech disfluency. The distribution in the word (initial–medial–final segment) seems to vary across languages based on morphological complexity, making it interesting to study segment prolongation in languages that exhibit different degrees of morphological complexity. In this paper we study segment prolongation in Hungarian, a language with very complex morphology. Our results indicated that distribution of prolongations according to their placements in words in Hungarian is comparable to English and Swedish, with a similar degree of morphological complexity, but not to Japanese or Mandarin Chinese, languages with a less complex morphology. Prolongations involve more vowels than consonants, more function words than content words, and word length does not influence the duration of the prolonged segment. Phonologically long vowels were produced shorter durations than phonologically short vowels. Finally, we suggest a 'phonotactics matters hypothesis", emphasizing the complexity of permissible syllable structures, which seems to be the main cause of the observed differences in how prolongation is realized in different languages.

Keywords: prolonged segments, place distribution, segment distribution, temporal properties, speech disfluency

1 Introduction

Speech timing is extremely complex involving rate, changes of rate, rhythm, continuity, naturalness, stability, breaks, etc. (Logan, 2015). Speech fluency, although never clearly defined, is really encountered in spontaneous speech, and one can only consider the use of filled pauses ("uh", "um") and segment prolongations (PRs), both frequently occurring in spontaneous speech. Segment prolongation has been shown to be one of the most common forms of (non-pathological) speech disfluency (Eklund,

2001). Prolongations frequently occur with other types of disfluent phenomena in everyday speech. Research on non-pathological segment prolongation has been carried out for a long time. Although formal studies began in the 1940s, it was during the 1950s when extensive and formal studies were more evident (see Eklund, 2004: 51–172). From the very start, the terminology has not been uniform, meaning that there is still no general agreement on how to classify the different types of disfluencies in existence. In addition, even the terms 'prolongation' or 'lengthening' themselves are not generally agreed upon. Although the phenomenon of prolongation is similar to filled pauses to a certain extent, there are essential differences between these two types of disfluency. Filled pauses (another term which is not universally recognized) are voiced, represent a small set of sounds and are often generally characteristic of the language. PRs have been shown to differ from filled pauses in some respects (e.g., Eklund, 2001; Clark & Fox Tree, 2002; Leeuw, 2007; Deme & Markó, 2013; Gósy et al., 2017). Filled pauses can occur between silent pauses and prolongations occur within various parts of words. Prolongations may affect any segment, both vowels and consonants, voiced and unvoiced speech sounds, and can appear in any word position.

One type of disfluency is recognized as segment prolongation, which means that a speech segment in a word is produced unusually long. This commonly used definition, however, seems to be vague (see van Riper, 1982). Prolongation cannot be properly defined from the aspect of articulation as the phrase "unusually long" suggests uncertainty in its timing. However, prolongation cannot be properly defined from the aspect of speech perception either, considering the listeners' ambiguous judgements about timing of segments in continuous speech (Jones et al., 2005; Bóna, 2007). There is no debate over the nature and existence of segment prolongation in typically speaking subjects' speech irrespective of language; however, the phenomenon itself is maintained by a perceptual sense of the listener. Listeners' temporal threshold for prolongation identification is largely different. Experiments have shown that listeners perceived sound prolongations along a continuum (Kawai et al., 2007). There are prolonged segments of a word that are intentionally produced but are not regarded as incidents of disfluency. Group data have revealed that listeners identified a segment to be prolonged when its original duration was exceeded by 38% (see Logan, 2015). Finally, it must also be borne in mind that perceived prolongation is dependent on speech rate, and thus needs to be calibrated against a durational framework, rather than being defined in absolute durational terms. Note that this is also the case for unfilled pauses/silences; see Eklund (2004:229–231).

What do we know about prolongations in speech based on various analysis of the phenomenon? Prolonged segments

(i) are relatively frequent in speech,
(ii) can occur on both vowels and voiced and unvoiced consonants
(iii) objective durations of the prolonged segments are not always decisive in recognition,

(iv) several factors definitely influence their recognition, such as articulation rate, fundamental frequency, intensity, phonetic context, segment quality, position in phrase, etc.

Prolonged segments in speech can be interpreted as interruptions of continuity against the usual timing of both the articulation and perceptual processes of the speakers/listeners. Reasons for the occurrence of prolongations seem to be the same as many other types of disfluency: the speaker needs time to overcome some speech planning or execution difficulty. Prolongations can be characteristic of some speakers leading to frequent occurrence in their speech while others that do not use this overcoming strategy frequently. Segment prolongations reflect the transitional lack of motor control of the speaker during speech planning as well as the strategy to gain extra time to solve the problem in speech planning.

The goal of this study was to analyze various patterns of Hungarian PRs, such as the number of occurrences, segment quality, word length, part of speech, duration of PR, and use by gender. One issue that has been discussed in the literature is which word segment tends to get prolonged. The first attempt to categorize PRs into different classes (see Eklund & Shriberg, 1998) was to analyze them in three different positions: word initial (the first segment of a word), word final (the last segment of a word) and word medial (any position that is not initial or final). The authors reported almost identical distribution across word position for American English and Swedish, with a 30–20–50% distribution (for initial–medial–final position, respectively). What made this figure interesting, however, was when studies of other languages started to appear. Eklund (2001, 2004) reported that the corresponding figures for distribution in Tok Pisin were 15–0–85%. Den (2003) reported 0–5–95% for Japanese, Lee and co-authors reported 4–1–95% for Mandarin Chinese (Lee et al., 2004).

Given the simpler morphology in those languages (especially for Japanese and Tok Pisin), Eklund (2004) proposed that PR distribution might be the function of the morphology in the language in which they appear, something Eklund called the "morphology matters hypothesis". Grammar and syntax, too, differ between those languages, so there might be other factors at play, and the "acid test" would then, of course, be to study languages that differ on both grammar/syntactic and the morphology continua. Hungarian is a language that is different from all of the languages mentioned above, therefore we decided to choose to analyze segment prolongation in Hungarian speech. We intended to verify the 'morphology matters hypothesis' as an effect of rich morphology on the distribution of prolonged segments in spontaneous speech.

Hungarian is an agglutinative language that belongs to the Finno-Ugric language family with an extremely rich morphology and an extensive system of affixation. The syntactic and semantic functions of noun phrases are primarily expressed via suffixes and postpositions. Case markings are used extensively with Hungarian nouns, but pronouns, adjectives, and numerals also take case and number markings. Verbs also have a considerable number of affixes (Kenesei et al., 2012). Hungarian words are

relatively long due to the rich morphology. There are three articles in the language, two of them are definite articles (*a* and *az* 'the') while one (*egy* 'a') is an indefinite article. The two forms of the definite articles appear dependent upon whether the following word begins with a consonant (like *a gyerek* 'the child') or a vowel (like *az utas* 'the traveller'), which is similar to a and an in English. The number of syllables in Hungarian words is 3.5 syllables on average in spontaneous speech (while the mean number of phonemes in words is 4.95). Words can easily consist of 9 or more syllables due to various suffixes and prefixes. The vowel inventory of Hungarian contains 14 vowels and 36 consonants; there are short-long phonemic pairs both in vowels and consonants. Finally, Hungarian is a 'syllable-timed' language where word stress invariably falls on the initial syllable although in connected speech not all words are stressed (Siptár &Törkenczy, 2000).

There are a few studies concerning PR characteristics in Hungarian that describe the occurrence of this phenomenon, its perceptual correlates (e.g., Bóna, 2007), the objective durations of the prolonged segments and their distribution over parts of speech (e.g., Gósy & Eklund, 2017). Results indicated that the frequency of prolonged segments (based on 18 adults' data) was 1.07 per minute (occurring every 123 words, see Gósy, 2003). In addition, more than 80% of the subjects in this study showed prolongations. The phenomenon was more characteristic of vowels than of consonants, PRs appeared most frequently on articles and conjunctions than any other parts of speech (Gósy, 2003; Bóna, 2008). Mean duration of prolonged vowels produced by 8 women (during a roughly 4-minute spontaneous speech sample each) was reported to be 286 ms, on average (Deme & Markó, 2013).

For the present study, the following questions were asked: What are the occurrence patterns of PRs in Hungarian? Does rich morphology affect the distribution of segment prolongations? Does the number of syllables in words affect the distribution of segment prolongation? We wanted to obtain information about the objective durations of prolonged phonologically short and long vowels.

We hypothesized that

(i) PRs would occur both on vowels and on consonants with a larger proportion on vowels (according to previous findings),
(ii) PRs would occur more frequently on function words than on content words,
(iii) PRs would show specific distributions with respect to their word positions,
(iv) The duration of PRs would not be influenced by word length or part of speech,
(v) The duration of PRs would be assumed to be influenced by segment quality, word position, and usage by gender.

2 Methods

2.1 Subjects

Thirty-six speakers (aged between 20 and 32 years; mean age: 26.1 years, std. dev.: 4.019; half of the speakers were females) participated in this study. They were randomly selected from the BEA Hungarian Spontaneous Speech Database (Gósy, 2012). All subjects were native monolingual speakers of Hungarian living in Budapest, and had a similar socio-economic status. Half of both females and males had mid-level education while the other half had university degrees. There were no indications of language or speech disorders for any of the participants. All of them had good hearing.

2.2 Speech materials

Various types of spontaneous speech materials were used in the analysis of prolongations including narratives, storytelling and a three-member conversation with each participant. One of the narratives was about the participant's life, family, job, and hobbies, while the participants talked about a topic of current interest in the other narrative and in conversations.

2.3 Recordings

Recordings were made in a sound-attenuated room (the same for all), under identical technical conditions using an AT4040 microphone connected directly to a computer using GoldWave to record samples at 44.1 kHz, 16 bits, monaurally. In all recordings the interviewer was the same young female phonetician. The duration of the analyzed spontaneous narratives for the present study was about 18.6 hours (31 minutes/speaker on average). The total duration of females' speech material was 9.9 hours while that of males' was 8.7 hours.

2.4 Analysis

All prolongations occurring in the 24-hour speech material were analyzed, both concerning vowels and consonants. Prolongations were identified by one of the authors and was checked by another phonetician, also a native Hungarian. 0.3% of disagreement was found in the identification of prolongations between the two phoneticians. These cases were excluded from further analysis.

Annotation was done manually using Praat software (Boersma & Weenink, 2015) according to criteria determined in advance. Vowel boundaries were marked between the onset and offset of the second formants of the vowels. Consonants were identified depending on their acoustic structures considering their voicing part (if any), burst, release, second formant information, and the neighborhood context, as appropriate. Duration measurements were carried out automatically using a specific script (Figure 1). The number of words in the speech material used for the present analysis was 92 826, and there were 2578 words per speaker, on average. Females' speech material contained close to 51 000 words while that of males' contained more than 41 000 words. Speakers produced 83 words per minute, on average. Females produced 86 words per minute, while males produced 80 words per minute, on average (containing various types of pauses).

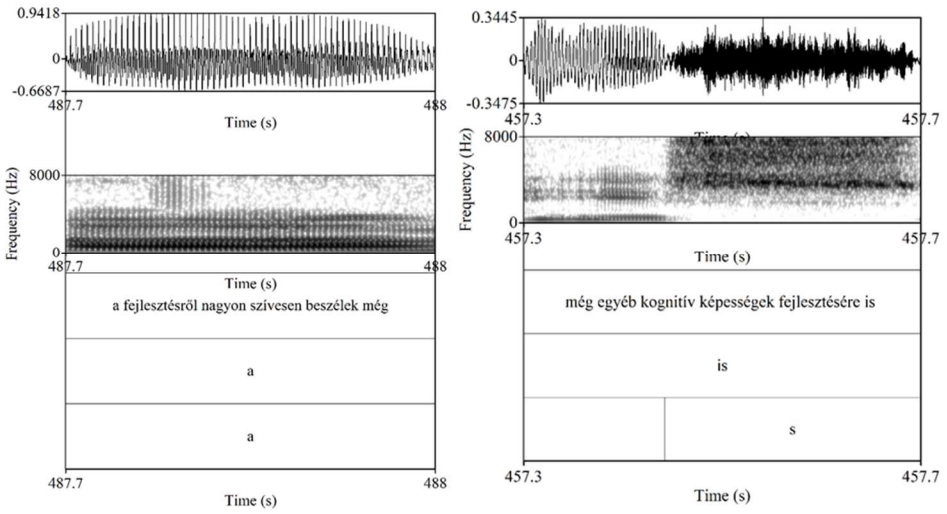

Figure 1.
Oscillograms and spectrograms of prolonged segments:
Vowel (left) and consonant (right)

Examples (prolonged segment is marked bold; the English equivalent of the target word containing the prolonged segment, is given right after the Hungarian word). We added examples of articles separate from those occurring in words.

Vowels:

(1) *olyan szülő**k**et* 'parents' *ismerek meg* 'I get acquainted with parents that'
(2) *egy tanító* 'teacher' *a faluban* 'a teacher in the village'
(3) *dolgoztam **é**s* 'and'
(4) *busszal ut**a**ztam* 'traveled' *tegnap* 'I traveled by bus yesterday'
(5) *ez az elektronikus könyvt**á**r* 'library' 'this is the electronic library'

Consonants:

(6) *huszonöt nagycsoporto**s*** 'preschool' *óvodás* 'twenty five preschool children'
(7) *tudod **m**ert* 'because' *nagyon elfáradtam* 'you know because I got very tired'
(8) *jó**l*** 'well' *éreztem magam* 'I worked and felt well'
(9) *hogya**n*** 'how' *lehet elérni* 'how can it be reached'

Articles:

(10) *csinálták **a*** 'the' *kettes villamost* 'tram number 2 was repaired'
(11) *ez **a*** 'the' *fő foglalkozásom* 'this is my main profession'
(12) *arról **a*** 'the' *tényről beszéltünk* 'we were speaking about that fact'

Six factors were considered for statistical analysis. Measured durations were the dependent variables while speech segment (vowel vs. consonant), word type (function vs. content), word position (initial, medial, final), word length (number of syllables of the words), and gender were the independent factors. GLMM method and Pearson's correlation were used (in SPSS 20.0 software). In all cases, the confidence level was set at the conventional 95%.

3 Results

3.1 Occurrences

A total of 948 prolongations were found in the analyzed speech material which is about 1% of all produced words. 779 PRs were found with various function and content words while the one-segment definite article (a) were prolonged in 169 cases. Males produced 448 PRs while 500 incidents were produced by females. The average incident of PRs was 26.3 per subject. Males produced 24.9 PRs per subject while females did 27.7 PRs per subject. The least number of the prolonged segments was 6 while the largest number turned out to be 77. Females produced 11 PRs as the least and 42 incidents as the largest number of PRs, while males produced 6 and 77 incidents, respectively. Considering the total duration of the analyzed speech material, the frequency of PRs turned out to be 1.18 incidents per minute with practically no difference between females and males (1.19 PRs/minute and 1.16 PRs/minute, respectively). Statistical analysis confirmed that no significant differences were found in the occurrences of prolongations between females and males (Z-score = –1.676, $p = 0.092$).

We also counted the occurrence of PRs by the number of words. Data show that every 93.4 words contained an incident of PR. Females produced them at every 84 words while males did so at every 102 words. Subjects showed enormous individual differences in the frequency of prolonged segments. No significant correlation was found between the number of PRs and the number of produced words in the subjects' speech materials. This finding suggests that irrespective of the number of words speakers produced, PRs occurred that were presumably characteristic of the subjects' individual strategy to overcome speech planning difficulties.

3.2 Position

Distributional patterns of analyzed PRs are shown in Table 1. The one-segment Hungarian definite article provides a categorization difficulty since "a" arguably falls in all three categories (initial, medial, final). Therefore its data are reported separately in the table. The general distribution observed (when the one-segment word, i.e. the definite article "a" is excluded from the analysis) is approximately 18–19–63%.

Since the definite article occurs between two words, and the last segment of the preceding word and the first consonant of the following word usually show co-articulation, we can take the liberty to analyze the one-segment article as being in a medial position. In this case the distributional patterns slightly change. As expected, the ratio of PRs in initial position decreases, in medial positions increases while the

ratio of PRs in final position is almost stable: 14.5–33.4–52%. This distribution is different from those languages in which the PRs have been analyzed in a similar way.

Table 1: PR distribution in words across positions

Position	Number of occurrences	Percentage of total number
Initial	138	17.7%
Medial	148	19.0%
Final	493	63.3%
"*a*" (article)	169	21.7%

3.3 Segments

We expected that the majority of the prolonged segments would be vowels which was indeed the case. Of all prolonged segments, 635 were vowels (66.9%) and 313 were consonants (33.1%). If we leave out the one-segment definite article and analyze just other words, the number of prolonged vowels is 466 (73.3%). The summary of these data are shown in Table 2 by decreasing occurrence. As can be seen, prolongation affects all possible types of segments, similar to what has been reported for English and Swedish. The majority of prolongations occurred with the relatively frequent vowels ([ɔ, ɛ, eː, i, aː]), altogether 80.1% of all occurrences. The order of vowels according to their relative frequency in spontaneous speech is [ɛ, ɔ, o, i, eː, aː]. There is only the [o] vowel missing as a relatively frequently prolonged vowel from those that are produced most frequently. However, the next one after [aː] is [o] according to our data (Table 2 and 3). Out of these frequently prolonged vowels there were three phonemically short vowels, while two of them were phonemically long vowels. The ratio of phonemically short vowels was 72.4% while those of phonemically long ones amounted to 27.6%.

Table 2: Vowel segments subject to prolongation, given in orthography and IPA and relative frequency given as percentages

Vowels (orthography)	IPA	Occurrences (%)
a	ɔ	37.1
e	ɛ	21.9
é	eː	13.0
i	i	10.3
á	aː	8.1
o	o	2.5
ó	oː	2.3
ő	øː	2.3
í	iː	0.9
ö	ø	0.3
ü	y	0.1
ú	uː	0.1

Table 3: Consonant segments subject to prolongation, given in orthography and IPA and relative frequency given as percentages

Consonants (orthography)	IPA	Occurrences (%)
s	ʃ	42.8
m	m	19.1
n	n	18.1
z	z	8.1
sz	s	3.7
h	h	1.8
gy	ɟ	1.2
k	k̟	1.2
f	f	0.9
l	l	0.9
ty	c	0.3
v	v	0.3
tt	tː	0.3
ny	ɲ	0.3
p	p	0.3
cs	tʃ	0.3

Phonemically long consonants are rare in Hungarian spontaneous speech (Beke et al., 2012), so we did not expect many PRs on them (actually we found just one, the [t:]). The frequent prolonged consonants ([ʃ, m, n, z]) partly align with those that are frequent ones in spontaneous speech (where the order is: [t, n, l, k, m, r, ʃ]).

3.4 Word type and number of syllables

As expected, prolongations occurred more frequently on function than on content words. Of all prolonged segments there were 371 occurrences on content words (39.1%) while 577 (60.9%) appeared on function words. The more frequent function words were conjunctions (*de* 'but', *hát* 'so', *és* 'and') and pronouns, some of them mainly in a filler function (*ilyen* 'such' meaning 'like', *ami* 'which').

Analysis was carried out on the interrelations of PRs and the number of syllables the words contained. Table 4 shows the occurrence of PRs according to the length of the words (expressed in number of syllables). The data in Table 4 summarizes the relative frequency of words with prolonged segments. The fewer syllables the words contained, the more prolonged segments occurred within them. In order to confirm this claim, a correlation analysis was carried out and resulted in significant relationships between the occurrence of prolonged segments and words with different lengths (Pearson's rho = 0.952, $p = 0.001$ at 99% confidence level).

Table 4: Prolongation as a function of the number of syllables in the affected word (given both as the number and of relative frequency of occurrences both for words with prolonged segments and words occurring in spontaneous speech)

N of syllables of words	Occurrences of words with prolonged segments	Occurrences of words in speech material	Ratio of words with prolonged segments (%)	Ratio of words in spontaneous speech (%)
1	589	13,925	62.1	45.0
2	181	8,664	19.1	28.0
3	101	4,796	10.6	15.5
4	56	2,320	6.0	7.5
5	16	928	1.7	3.0
6	2	495	0.2	1.6
7	3	371	0.3	1.2

3.5 Temporal patterns of prolonged segments

Measured durations of the prolonged segments showed that vowels were longer than consonants (Figure 2). The mean duration of the vowels was 303 ms (SD = 101 ms) while that of the consonants was 286 ms (SD = 119 ms). The figure shows that there is a large overlap in the duration of vowels and consonants. The difference was significant ($F(1, 947) = 5.314$, $p = 0.021$). There was also a significant difference between females and males in segments' durations ($F(1, 947) = 14.460$, $p = 0.001$). Their interaction turned out to be significantly different, too ($F(1, 947) = 10.789$, $p = 0.001$).

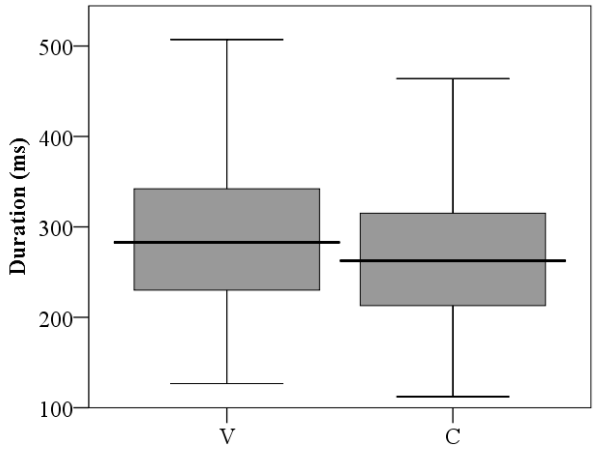

Figure 2.
Durations of PRs broken down by vowels and consonants (medians and ranges)

Although some of the vowels and the consonants in Hungarian form phonologically short–long pairs, temporal analysis was carried out only with vowel pairs. (As we mentioned earlier, there was only one phonemically long consonant prolonged in our material.) The mean duration of the phonemically short vowels turned out to be 312 ms (SD = 105 ms) while that of the phonemically long vowels was 271 ms (SD = 74 ms). The results of the statistical analysis showed a significant difference in durations between phonemically short and long vowels that were prolonged in spontaneous speech ($F(1, 634) = 22.280$, $p = 0.001$). Despite the overlapsof durational data, phonemically short vowels turned out to be longer than phonemically long vowels quite unexpectedly (Figure 3).

Analysis of prolongations by word type revealed that prolonged segments were shorter when occurring in content words than in function words. The mean duration of prolonged segments in content words was 283 ms (SD = 106 ms) while that in function words was 306 ms (SD = 107 ms). To distinguish the vowels and consonants, the measured data showed the following pattern. The mean duration of prolonged vowels in content words was 269 ms (SD = 77 ms) while those in function words was 320 ms (SD = 107 ms). The mean duration of prolonged consonants in content words was 300 ms (SD = 134 ms) while those in function words was 270 ms (SD = 99 ms). This pattern compares well with proposed theories that hesitation occurs whenever important choices are made in speech production, sometimes referred to as the "many-options hypothesis" (see e.g., Eklund & Wirén, 2010). Despite the differences found in objective durations between content words and function words, this difference was not significant.

In the next step of analysis we concentrated on the length of words that contained prolonged segments. As Table 3 shows, prolongations occurred mainly in words with 1, 2, 3 and 4 syllables, therefore the duration analyses will be focused on these words. There was no significant difference depending on word length ($F(6, 947) = 2.095$,

$p = 0.052$); however, pair-wise tests confirmed a significant difference in the duration of prolonged segments within monosyllables compared to disyllabic words ($p = 0.04$). In general, we can claim that word length was not a factor influencing PR durations (Figure 4). The durations of the prolonged definite articles (*a* 'the') were longer than those of all other monosyllables (344 ms, on average vs. 291 ms, respectively). Durations of prolonged segments by various word lengths were not significantly different between females and males.

The position of prolonged segments in the words was identified as a decisive factor influencing objective durations (Figure 5). Statistical analysis confirmed that word position was a significant factor influencing the duration of prolonged segments ($F(3, 947) = 18.038$, $p = 0.001$). Pair-wise tests, however, showed that there were significant differences in segment durations (i) between definite articles and all the other prolonged segments occurring in other positions ($p < 0.05$ for all), and (ii) between medial and final positions ($p < 0.05$).

As we have seen earlier, the durations of the definite articles were longer than all the other prolonged segments, and the durations of prolonged segments in medial positions were shorter than those occurring both in initial and final word positions (however, only the latter turned out to be significant). Note that in this case not only position but two other factors – the definite article is a monosyllable and also a vowel – might have influenced the temporal patterns. Durations of prolonged segments depending on position were not significantly different between females and males.

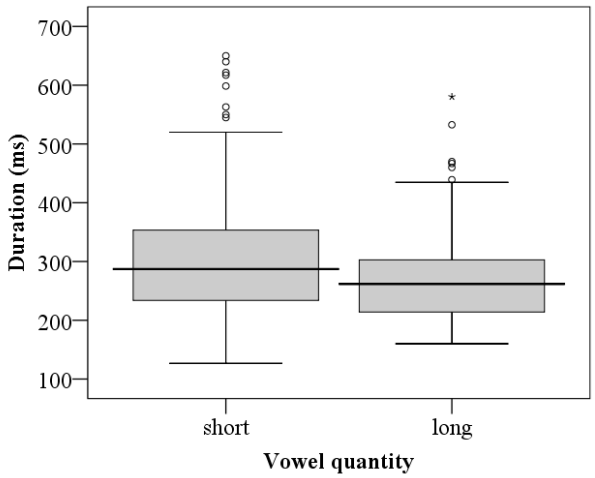

Figure 3.
Durations of prolonged phonemically short and long vowels (medians and ranges)

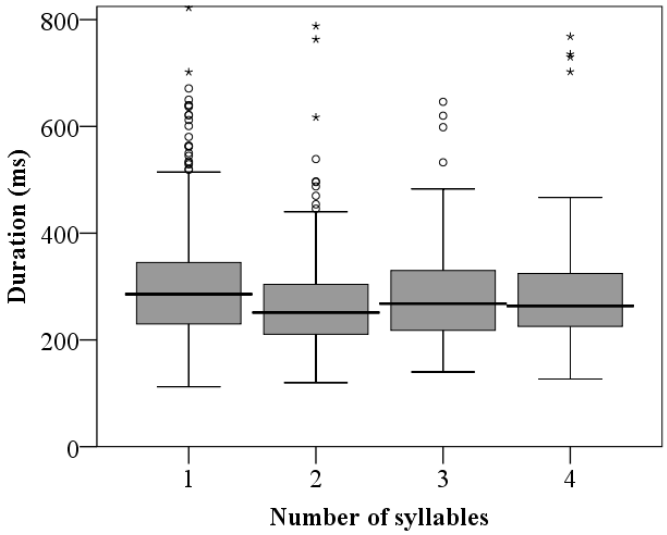

Figure 4.
Durations of prolonged segments according to the lengths of words they occurred on (medians and ranges)

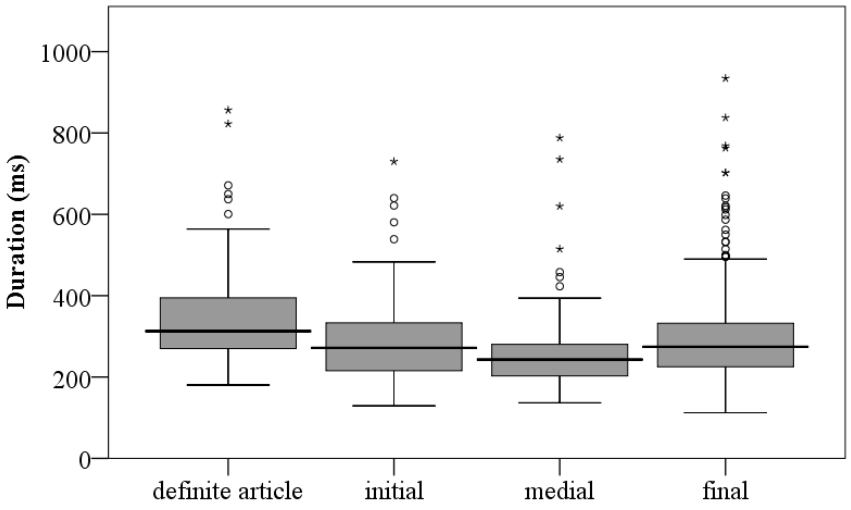

Figure 5.
Durations of prolonged segments according to positions (medians and ranges)

4 Discussion and conclusions

1. Segment prolongation has been shown to be one of the most common forms of non-pathological speech disfluency (Eklund, 2001). Prolongation is a common strategy used by speakers to overcome speech planning and execution difficulties during

spontaneous speech. In this paper, 948 prolongations observed in Hungarian were analyzed by several aspects. Our results showed that PRs affected more vowels than consonants, and more function words than content words. Phonologically long vowels were shorter than phonologically short vowels. Word length did not influence the duration of the prolonged segment. The distribution of PRs by word position (initial–medial–final segment) seems to vary among languages of different morphological complexity, making it interesting to study segment prolongation in languages that exhibit different degrees of morphological complexity. Our results indicate that distribution of prolongations in Hungarian is similar to English and Swedish, but not Japanese or Mandarin Chinese. We have found no gender differences in our analysis, either in the occurrences or in the durations of PRs.

2. PRs were relatively frequent in our speech material, constituting roughly one word with a segment prolongation per minute. Although females produced more PRs than males (500 vs. 448 incidents), their frequency (occurrence per minute) showed no difference depending on gender. However, if we look at the occurrence considering the words speakers produced, a large difference was found between females and males: PRs occurred more frequently in females' speech with the difference of 18 words. These figures do not provide a possibility to form a proper explanation for this finding. We might only speculate that prolongation is a more common strategy in females than in males.

We hypothesized that PRs would occur more frequently on vowels than on consonants based on former findings in Hungarian (Bóna, 2008) which is unlike the findings that are reported for American English, Swedish (see Eklund & Shriberg, 1998) or German (see Betz et al,. 2017). German speakers prefer prolonging consonants, mainly sonorants and fricatives more frequently (53.8%) than vowels (44.3%). For Hungarian, the assumption of the more frequent vowel prolongations could be confirmed. Specifically, we defined three factors as being responsible for more PRs on vowels (about 66%) than on consonants in Hungarian:

(i) vowels function as syllable nuclei,
(ii) it is easy to articulate them longer as opposed to those of some consonants, and
(iii) some function words provide the possibility of prolonging their vowels rather than their consonants, like *és* 'and', *de* 'but', *hát* 'well'.

Interestingly, however, no prolonged [t] was found in our material, and all the other stop consonants were poorly represented among prolonged consonants. These facts suggest that prolongation can be explained by the lexical access and/or morphologic/syntactic planning difficulties of the speaker, but it is not concerned with particular segments. The data showed that the occurrence of various prolonged segments did not follow any systematic rule. The occurrence of prolongations seemed to be connected with the relative frequency of phoneme realizations in the case of vowels while other factors affected the types of consonants that were prolonged in speech. Consonants that have a frication articulation gesture (such as [s, z, ʃ]) or are

articulated with continuous expiration (such as [m] and [n]) are more likely to be prolonged than those having a closure somewhere in the vocal tract. In addition, there were function words containing these consonants that are relatively frequent, like *és* 'and', *ez* 'this', *ilyen* 'such', *nem* 'no'.

3. Concerning the distribution of PRs according to their word position, there is a remarkable similarity between our results from Hungarian and previous reports on American English and Swedish (Eklund & Shriberg, 1998). This was a bit different from that of German, and particularly different when compared to the reported figures from Tok Pisin, Japanese and Mandarin Chinese (Den, 2003; Lee et al., 2004). So, at first glance it would seem that the proposed "morphology matters hypothesis" is supported in the present study. Distributional data of Hungarian – which are 18–19–63% – are similar to those of American English and Swedish (30–20–50%). However, the ratio of the initial occurrences is less while the ratio of final occurrences is larger in Hungarian than both in Swedish and English (Eklund & Shriberg, 1998). However, recent results from German where the distribution 7–15–78% (Betz et al., 2017) seemed to point in another direction, and suggested that at least a strong version of the "morphology matters hypothesis" is not entirely supported. Since German and Swedish have very similar morphology – more similar than that of Hungarian and Swedish – and both exhibit phenomena like frequent and creative compounding, it would seem that either morphology alone cannot explain the observed differences in distribution or, further investigations are needed to find those similarities and differences in morphology that might be responsible for the distributional data. We assume that the stable first syllable stress in Hungarian speech might explain the distributional differences of the initial segments. The speakers are not supposed to prolong the stressed vowel because this might add further emphatic or stylistic color to the actual word, and might modify the word's basic meaning. The stress patterns of Hungarian might explain also the occurrence of the final PRs that are less than in German and more than in American English and Swedish. When comparing Hungarian data to the figures reported from Tok Pisin, Japanese and Mandarin Chinese (15–0–85%, 0–5–95%, 4–1–95%, respectively, see Den 2003; Lee et al. 2004), the distribution is largely different.

Finally, considering our present results and also recently published findings for German, we suggest a revision to the original "morphology matters hypothesis" since phonotactics, that is the complexity of permissible syllable structures, seems to be the main cause of the observed differences in prolongations across languages. Although Swedish can create very long (final) consonant clusters by stringing grammatical morphemes one after the other (reaching a maximum number of 8 word-final consonants), it is rather the phonotactics that matters, rather than morphology. Hungarian is a language of extreme morphological complexity, but, again, syllable complexity seems to be decisive in prolongations. Comparing the realizations of different segments and their positions in the word when they are prolonged across diverse languages, syllable complexity matters and can explain the language-specific

findings. This view seems to be much better suited to account for the reported differences in PR distributions across languages, and should consequently be rephrased as "phonotactics matters hypothesis", as already hinted at in Betz et al. (2017: 14).

In addition, it must be pointed out that the reported figures for various comparisons with other languages might have some limitations based on the kind of speech material used. For example, the American English and Swedish data used by Eklund and Shriberg (1998) were all telephone data, and disfluency in dialog over a telephone line, where interlocutors cannot make use of visual cues, might be different from disfluencies in face-to-face dialog like in the Hungarian data. The Tok Pisin data presented in Eklund (2001) were all spontaneous face-to-face dialogs between authentic customers and (real) travel agents and represented data of high ecological validity. The German data was based on a directed speech task (Betz et al., 2017).

4. We hypothesized that PRs would occur more frequently in function words than in content words. That was again confirmed. Quite interestingly, the ratios of prolonged function/content words were almost the same in German and Hungarian (62.4% and 60.9%, respectively); however, we think that the reason lies in higher cognitive processes, irrespective of language. In Hungarian, content words are highly variable (due to their rich morphology) and in general longer (as to the number of syllables they possess) than function words. Therefore, the invariable form of function words, as well as their role in phrases, provides a better place for PRs than content words. In addition, prolongation might provide extra semantic, stylistic content to the word if it is a content word, while this is not the case with function words. Repetitions, which are similar strategies to prolongations in overcoming planning difficulty, include more function words than content words (Gyarmathy, 2017).

5. As for durations in prolonged segments, vowels are, on the whole and perhaps not surprisingly, more prolonged than consonants in our data. This difference was statistically confirmed. Despite the overlaps in durational data, phonemically short vowels turned out to be longer than phonemically long vowels quite unexpectedly. The difference was 40 ms, on average. The questions then arises: Why do speakers articulate short vowels longer than long vowels? Our explanation is that prolongation of phonemically long vowels might lead to a very artificially sounding segment, and speakers try to unconsciously keep, the physical durations within a limited framework in order not to emphasis their lengthening. They are, however, not so careful in the case of short vowels which results in really long segments. Although we did not measure the physical durations of non-prolonged speech sounds in our subjects in this study, a careful comparison – based on spontaneous speech samples produced by subjects from the same BEA database (e.g., Beke & Gósy, 2014; Gósy & Krepsz, 2017) – shows that phonemically short vowels are prolonged by about 4.3 times of their non-prolonged durations while phonemically long vowels are prolonged by about 2.6 times than those of their non-prolonged durations.

The longer durations of the prolonged segments occurring on monosyllables might be the fact that monosyllables are, in general, longer than all the other words with more syllables (e.g., Gósy & Krepsz, 2017). The result that the durations of the definite articles were longer than those of other monosyllables by more than 50 ms, on average, can be explained by the fact that they occur frequently between two pauses which is not characteristics of other monosyllables.

The durations of prolonged segments in the initial and final positions and between the definite articles and those occurring in other word positions were significantly different. Both word-final lengthening and word initial stress might have some effects on the temporal patterns of the prolonged segments. However, since only the very first and the very last prolonged segments were considered in these positions, there also could be other factors influencing the durations of the prolonged segments in different positions. There is another explanation for these results that concerns the speech planning mechanism. If there is any speech planning difficulty realized by the speaker (consciously or unconsciously) at the beginning of lexical access, the speaker tries to gain extra time by prolongation of the very first segment. In other words, prolongations of initial segments might refer to identified disharmony within speech planning prior to execution. The prolongation of the final segment of the word might be in connection with continuation problems or difficulties in lexical access of the next word. These reasons seem to increase the durations of the initial and final segments of the words.

We think that our paper not only sheds light on specific patterns of segment prolongation but also reveals many new details about the nature of disfluency in a morphologically complex language. It is our hope that future studies will provide even more insights into segment prolongation in non-pathological speech.

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References

Beke, A. & Gósy, M. 2014. Phonetic analysis and automatic prediction of vowel duration In: Hungarian spontaneous speech. *International Journal of Intelligent Decision Technologies, 8*, 301-314.

Beke, A., Gósy, M. & Horváth, V. 2012. Gyakorisági vizsgálatok spontán beszédben. [Analyses of the frequency of occurrence of various phenomena in spontanoues speech] *Beszédkutatás 2012,* 259-276.

Betz, S., Eklund, R., & Wagner, P. 2017. Prolongation in German. In: *Proceedings of the 8th Workshop on Disfluency in Spontaneous Speech, DiSS 2017*, TMH QPSR 58, 13-16.

Boersma, P. & Weenink, D. 2015. *Praat: doing phonetics by computer.* http://www.praat.org (Accessed 2014).

Bóna J. 2007. Magánhangzó-nyújtások akusztikai-fonetikai paraméterei a spontán beszédben. [Acoustic-phonetic parameters of vowel prolongations in spontaneous speech] *Beszédkutatás 2007*, 99-107.

Bóna, J. 2008. A nyújtás sajátosságai a dadogó és az ép beszédben. [Characteristics of prolongations in stuttering and typical speech] *Beszédkutatás 2008*, 148-156.

Clark, H. H., & Fox Tree, J. E. 2002. Using *uh* and *um* in spontaneous speaking. *Cognition, 84,* 73-111.

Deme, A. & Markó, A. 2013. Lengthenings and filled pauses in Hungarian adults' and children's speech. In: Eklund, R. (ed.): *Proceedings of Disfluency in Spontaneous Speech*, DiSS 2013, 21-24.

Den, Y. 2003. Some strategies in prolonging speech segments In: spontaneous Japanese. In: R. Eklund (ed.): *Proceedings of DiSS'03, Disfluency in Spontaneous Speech*, 5–8 September 2003, Göteborg, Sweden. *Gothenburg Papers In: Theoretical Linguistics 90*, ISSN 0349-1021, 87-90.

Eklund, R. 2001. Prolongations: A dark horse in the disfluency stable. In: *Proceedings of DISS 2001, Disfluency in Spontaneous Speech*. 29-30 August 2001, Edinburgh, 5-8.

Eklund, R. 2004. *Disfluency in Swedish human–human and human–machine travel booking dialogues*. PhD thesis, Linköping University, Sweden. ISBN 91-7373-966-9, ISSN 0345-7524.

Eklund, R. & Shriberg, E. 1998. Crosslinguistic Disfluency Modelling: A Comparative Analysis of Swedish and American English Human–Human and Human–Machine Dialogues. *Proceedings of ICSLP 98*, 30 November – 5 December 1998, Sydney, Australia, 6: 2631-2634.

Gósy, M. 2003. A spontán beszédben előforduló megakadásjelenségek gyakorisága és összefüggései. [Frequency and interrelations of disfluencies occurring in spontaneous speech] *Magyar Nyelvőr*, 127, 257-277.

Gósy, M. 2012. BEA – A multifunctional Hungarian spoken language database. *The Phonetician, 105/106,* 50-61.

Gósy, M. & Krepsz, V. 2017. *Morfémák időzítési mintázatai a beszédben.* [Temporal patterns of morphemes in speech] MTA Nyelvtudományi Intézet. Budapest.

Gósy, M. & Eklund, R. 2017. Segment Prolongation in Hungarian. In: Eklund, R. & Rose, R. (eds.): *Proceedings of the 8th Workshop on Disfluency in Spontaneous Speech, DiSS 2017*, Stockholm: TMH QPSR 58, 29-32.

Gósy, M., Gyarmathy, D., & Beke, A. 2017. Phonetic analysis of filled pauses based on a Hungarian–English learner corpus. *International Journal of Learner Corpus Research, 3*(2), 151-176.

Gyarmathy, D. 2017. Megakadásjelenségek a magyar spontán beszédben. [Disfluency phenomena in Hungarian spontaneous speech] MTA Nyelvtudományi Intézet. Budapest.

Jones, K., Logan, K. J., & Shrivastav, R. 2005. *Duration, rate, and phoneme-type effects on listeners' judgments of prolongations*. Poster presented at the annual meeting of the American Speech–Language–Hearing Association, San Diego, CA.

Kawai, N., Healey, E. C., & Carrell, T. D. 2007. Listeners' identification and discrimination of digitally manipulated sounds as prolongations. *Journal of the American Acoustic Association, 122,* 1102-1110.

Kenesei, I., Vago, R, & Fenyvesi, A. 2012. *Hungarian*. New York: Routledge.

Lee, T.-L., He, Y.-F., Huang, Y.-J., Tseng, S.-C., & Eklund, R. 2004. Prolongation in spontaneous Mandarin. In: *Proceedings of Interspeech 2004*, 4-8 October 2004, Jeju Island, Korea, vol. III, 2181-2184.

Leeuw, E. 2007. Hesitation Markers in English, German, and Dutch. *Journal of Germanic Linguistics*, *19,* 85-114.

Logan, K. J. 2015. *Fluency Disorders*. San Diego, CA: Plural Publishing Inc.

Riper, van C. 1982. *The Nature of Stuttering*. Englewood Cliffs, NJ: Prentice-Hall.

Siptár, P. & Törkenczy, M. 2000. *The phonology of Hungarian*. Oxford: Oxford University Press.